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(NASA-TM-80016) OAST SPACE THEME WORKSHOP.

N79-15128

VOLUME 3: WORKING GROUP SUMMARY. 9:

AEROTHERMODYNAMICS (M-3). A: STATEMENT.

B: TECHNOLOGY NEEDS (FORM 1). C. PRIORITY

Unclas

ASSESSMENT (FORM 2). D. ADDITIONAL (NASA) G3/12

42669

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OAST SPACE THEME WORKSHOP

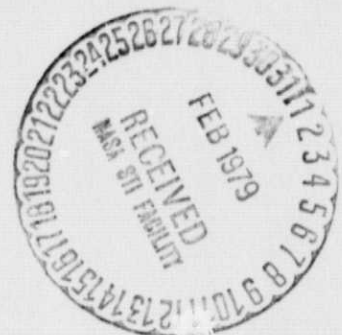
VOLUME III

WORKING GROUP SUMMARY

IX. AEROTHERMODYNAMICS (M-3)

- A. STATEMENT
- B. TECHNOLOGY NEEDS (FORM I)
- C. PRIORITY ASSESSMENT (FORM II)
- D. ADDITIONAL ASSESSMENTS

HELD AT THE
LANGLEY RESEARCH CENTER
APRIL 26-30, 1976



SPONSORED BY NASA-CODE RX

Foreword

The attached material represents the working papers from the OAST Space Theme Workshop held at the Langley Research Center, April 26-30, 1976, and contains a quick-look analysis of the proceedings. The material is unedited and intended for further use by the participants of the workshop and the planning elements of NASA concerned with space mission research and technology. It should be understood that the data do not represent official plans or positions but are part of the process of evolving such plans and positions.

Nearly 100 of the Agency's top technologists and scientists joined with another 35 theme specialists to produce this working document - a document that provides a technical foundation, including research and technology base candidates, for each of the six space themes.

The material in this report is considered essential to the development of Center initiatives in support of these themes. Copies of the report will be made available to the Center Management Board and the individuals at the Centers responsible for the FY'78 program planning cycle. The timing of this planning activity has caused us to distribute this document in this unedited form. Thus, it possibly contains errors, hopefully, more of a typographical rather than a technological nature. Nonetheless, the information contained is of a high professional level, reflecting the efforts of the workshop participants and will be invaluable to the planning and successful execution of the Agency's near- and far-term advanced technology program.

Stanley R. Sadin
OAST Space Theme Workshop
Chairman
NASA Headquarters
Study, Analysis, & Planning Office
Office of Aeronautics and
Space Technology

Aerothermodynamics (M-3)

SUMMARY

In Theme #10, Solar System Exploration, and Theme #12, Advanced Space Transportation Systems, where space vehicles encounter the Earth and other planetary atmospheres at high speed, the aerothermodynamic heating and aerodynamic forces are of a sufficiently uncertain magnitude as to necessitate concern by the OAST Space Technology Workshop. The space vehicles considered by the Workshop requiring development of aerothermodynamic technology were the space transportation systems, including heavy launch vehicles, orbital transfer vehicles, and advanced earth-to-orbit launch vehicles; and planetary atmospheric vehicles including probes, planetary surface landers, and sample return vehicles. The OAST aerothermodynamic space technology needs identified by the Workshop are those which will significantly reduce the design uncertainties in aerothermodynamic heating and aerodynamic forces experienced by these future space vehicles.

Concerning the Advanced Space Transportation Theme #12, the Aerothermodynamics Working Group and Theme Teams have found OAST space technology needs including the accurate establishment of aerothermodynamic design criteria, the development of optimum configurational characteristics, the determination of TPS wall surface effects, and the development of experimental techniques to study aerothermodynamic phenomena during operational space shuttle flights. The identified OAST technology needs now being pursued at the NASA ARC and the NASA LaRC are about 30 percent less

than desired. A major deficiency of the current OAST program is that RCS effects, plume effects, and base flow problems have been neglected.

The Working Group has examined and highly recommends the new initiatives submitted prior to this Workshop which are responsive to the Advanced Space Transportation Theme. These are: No. 108, The Measurement of Shuttle Windward Heating by an Airborne IR System; No. 113A, The Measurement of Shuttle Leaside Heating by an On-Board IR Camera; and No. 113E, The Improved Air Data System for Sensing Flight Conditions. The Working Group concludes that each of these new initiatives should be started in FY 78. In addition, a new initiative for FY 79 to develop a technology base for advanced earth-orbit transportation has been recognized. The objective of this initiative is to enable improved performance of the STS to achieve at a payload cost of \$20 per pound in low earth orbit.

The examination of Solar System Exploration Theme #10 by the Workshop identified OAST aerothermodynamic technology needs for planetary vehicles. Atmospheric probes beyond Viking, Pioneer Venus, and the Jupiter probe, and earth sample return vehicles planned for about 1988 require significant refinements in aerothermodynamics and aerodynamics. The design improvements will require a major advance in knowledge of heating and flow fields including heat-shield ablation material interactions. Planetary subsurface probes (penetrators) entering planetary atmospheres will need light hypersonic and low-speed decelerators to reduce and control impact speed. For planetary surface soft landers, the Workshop identified needs related to maximizing payload and overcoming adverse rocket plume-planetary surface interactions. A new initiative, Shuttle-Launched Experimental Reentry

Systems, was recognized by the working group. The purpose of the reentry system will be to provide aerothermodynamic data to validate analysis and ground experimental data related to atmospheric entry probes and planetary sample return vehicles. In addition, this system is also supporting the needs of the Advanced Space Transportation Theme. The approach will be to develop modularized, building block booster elements, a basic experimental measurements package, an avionics guidance and command package, and a retrieval capability. This system should provide great flexibility in the specification of external configuration and reentry conditions. Emphasis will be placed "piggy-back" operation with other shuttle payloads so that flight test data can be obtained at significantly reduced cost.

The Workshop identified three OAST aerothermodynamic technology needs related to the R&T Base Theme #1. These needs were to increase the computational fluid dynamics capability by at least two orders of magnitude by developing an advanced computer processor for the solution of fluid dynamic problems with improved software. This new initiative was submitted prior to the Workshop and bears the identification no. 202. A need to predict multi-engine base flow fields for launch vehicles was also identified by the Working Group. With the energy reduction program now in effect within NASA, the Workshop identified a need to develop methods to conserve energy in aerothermodynamic ground test facilities or else face a significant reduction in operations. The technology development concerning energy conservation will be directed at modifying existing NASA aerothermodynamic facilities to increase facility effectiveness.

In summary, 12 OAST aerothermodynamic technology needs were identified by the Working Group and Theme Teams. Of these, four were concerned with Theme #12, Advanced Space Transportation Systems, five were identified from Theme #10, Solar System Exploration, and three R&T base needs were indicated. The plans to pursue these needs are described on forms developed by the Workshop and are located within the appendix.

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

(List in numerical order, 1 - Highest Priority)

FORM II
FORM III

WORKING GROUP M-3

DATE 4 / 28 / 76

THEME NO. TECHNOLOGY NEED NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV. TRANS SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT	
							Current	R&T Base	WG	TT
1-M-3-1 (Increase Comp. Fluid Dyn. Capability)	N/A	N/A	N/A	N/A	N/A	N/A		1	6	
1-M-3-2 (Calculate Multi-Engine Base Flow)								3	8	
1-M-3-3 (Dev. Energy Cons. Aero. Test Fac.)								2	7	
10-M-3-1 (Atm. Probes/Earth Return-Heating and Flow Field Def.)				1			✓		3	
10-M-3-2 (Atm. Probes/Earth Return - Dev. of Stable Config.)				2			✓		5	
10-M-3-3 (Surface Landers - Dev. Penetrator Config.)				3					9	
10-M-3-4 (Surface Landers - Plume/Surface Integration)				4					10	
10-M-3-5 (Surface Landers - Aerody. Config.)				5		✓	✓		11	
12-M-3-1 (Est. Aero-thermo Des. Criteria)				N/A		1	✓		1	
12-M-3-2 (Adv. Sts - Config. Char.)						3	✓		4	
12-M-3-3 (Adv. Sts - Improved Multi-Mission TPS)						4	✓		12	
12-M-3-4 (Adv. Sts - Verif. Aerothermo. by flight test)	✓	✓	✓			2	✓		2	

5. COMPONENT OR STANDARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
 6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
 7. MODEL TESTED IN SPACE ENVIRONMENT
 1. BASIC PHENOMENA OBSERVED AND REPORTED
 2. THEORY FORMULATED TO DESCRIBE PHENOMENA
 3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
 4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1
 PAGE 1 OF 3

1. TITLE Advanced STS - NO. 12 M-3 1
Establish Aerothermodynamic Design Criteria THEME / W.G. / TASK
 DATE 4 / 26 / 76

2. OBJECTIVE
To develop prediction techniques based on a complete understanding of flow phenomena to enable the development of accurate design criteria

3. NEED ANALYSIS
 a) LEVEL NOW 4, WILL BE LEVEL 5 UNDER EXISTING PLANS.
 b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1990
 c) RISK IN ACHIEVING ADVANCEMENT:
 HIGH ☐ MEDIUM ☒ LOW ☐
 d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
 e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
 GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒
 OTHER (Specify) ☐ (Check one or more)
 f) R&T BASE CANDIDATE \$700K 506-26

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Orbiter Experiment Payloads must be implemented.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Develop 3-D real gas flow-field diagnostics
Determine boundary layer transition criteria
Improve understanding of viscous interaction and real gas effects
Determine separated flow analysis
Improve lee surface heating analysis
Reduce uncertainties in windward surface heating
Improve analysis of rocket plume impingement heating and interference effects.
Improve base-flow analysis
Devise new measurement techniques
Improve gasdynamic and reaction kinetics analysis related to environmental pollution.

FORM NO. 1
PAGE 2 OF 3

TITLE Advanced STS -

NO. 12 M-3 1

THEME / W.G. / TASK

~~Establish Aerothermodynamic Design Criteria~~

DATE 4 /26 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Continued research in basic aerothermodynamics both experimental and computational. Experiments will be conducted in ground base facilities and in flight on-board the Orbiter.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Orbiter Experiments 750-01, 750-03

Space Shuttle Config. & Aerothermo. 506-26-31

Advanced E. O. Transport Technology 506-26-10

9. TECHNOLOGY SCHEDULES

[illegible][illegible]

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 3 OF 3

1. TITLE Advanced STS -

NO. 12 M-3 1

Establish Aerothermodynamic Design Criteria

THEME / W.G. / TASK

DATE 4 / 26 / 76

(9) CONTINUATION (If Needed)

Block No.

FY
76

85

Schedule Item

Measurement Techniques

▲

▼

Environmental Pollution

▲

▼

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Advanced STS - Definition of Configuration NO. 12/M-3/2

Characteristics

THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE Develop parametric data base for candidate configurations to achieve "optimal" design.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☒ LOW ☐d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒ GRD TEST ☒ AIR CRAFT TEST ☒ SPACE FLIGHT TEST ☒OTHER (Specify) ☐

(Check one or more)

f) RST BASE CANDIDATE \$400K 506-26

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Adequate flight instrumentation is required on orbiter to verify test and analysis methods.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- Control configured vehicle design criteria
- Canard/wing coupling for various planforms from hypersonic through subsonic flight
- Vehicle design landing speed criteria
- Canard/canard flap control effectiveness for various planforms throughout Mach regime
- Canard/high lift wing device coupling during subsonic flight
- Propulsive/aerodynamic coupling effects for propulsive assisted glide vehicles

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FORM NO. 1
PAGE 2 OF 2

TITLE Advanced STS - Definition of Configuration Characteristics

NO. 12 M-3 2
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Validate current test and analysis methods by comparing orbiter characteristics theoretical predictions, wind tunnel test data, and orbiter experiments flight test data. Develop parametric data base for candidate STS configurations through application of current and enhanced fluid dynamics and flow fields computational techniques, and test simulation and testing techniques.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Orbiter experiments

9. TECHNOLOGY SCHEDULES

[illegible]

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Advanced STS - Determination of TPS
Wall Surface Effects

NO. 12/M-3/3
 THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE To develop the technology for TPS systems of improved
reusability.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY
 AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☒ LOW ☐d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
 ENHANCING: HIGH ☐ MEDIUM ☒ LOW ☐e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
 GND TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒
 OTHER (Specify) ☐ (Check one or more)f) ESTIM. USE CANDIDATE \$100K 506-264. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
 USE OF THIS TECHNOLOGY5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
 ACCOMPLISH NEEDUnderstanding of wall catalyticityDevelopment of lighter-weight, fully reusable TPS

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1. TITLE
 2. OBJECTIVE
 3. NEED ANALYSIS
 4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
 USE OF THIS TECHNOLOGY
 5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
 ACCOMPLISH NEED

1. TITLE
 2. OBJECTIVE
 3. NEED ANALYSIS
 4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
 USE OF THIS TECHNOLOGY
 5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
 ACCOMPLISH NEED

FORM NO. 1

2

NO. 12 M-3 2

THEME / W.G. / TASK

DATE 4 / 26 / 76

If the chemical recombination of oxygen at the surface of an advanced STS could be avoided considerable weight could be saved in the TPS. The definition of surface catalyticity requires research in ground-based arc jets, shock tubes, and in flight on the Orbiter.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Orbiter experiments	750-01, 750-03
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FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
OEX calatytic wall		v				A														
Ground-Based Research										R					D					

[illegible]

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Advanced STS - Verification of Aerothermal NO. 12/M-3/4
Performance by Flight or Advanced Ground THEME / W.G. / TASK
Test DATE 4 / 27 / 76

2. OBJECTIVE Develop the techniques for accurate measurements of aerothermal environments in flight and advanced ground test facilities.

3. NEED ANALYSIS

- a) LEVEL NOW [4], WILL BE LEVEL [7] UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY
AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1980]
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☐ LOW ☒
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☒ SPACE FLIGHT TEST ☒
OTHER (Specify) ☐ (Check one or more)
f) RST BASE CANDIDATE \$1000K FY 77 750-01, 750-03

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Remote IR imagery by airborne systemsLeeside IR imagery systemImproved Air Data SystemImproved Aerodynamic Data Extraction

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FORM NO. 1

2

NO. 12 M-3 4
THEME / W.G. / TASK

DATE 4 / 26 / 76

IMPLEMENTATION OF OEX EXPERIMENTS AS RECOMMENDED BY THE AEROTHERMAL GROUP
AT THE OEX WORKSHOP IN THE ORDER OF PRIORITY INDICATED BY THAT GROUP.

IR IMAGERY OF WINDWARD HEATING	750-01
LEESIDE IR IMAGERY	750-03

FY

[illegible]

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE R & T Base - Increase Computational
Fluid Dynamics Capability

NO. 1/M-3/1

THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE To increase computational capability for fluid dynamic
problem by two orders of magnitude.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [7] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1982]

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH [] MEDIUM [X] LOW []

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR
ENHANCING: HIGH [X] MEDIUM [] LOW []

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]

GRD TEST [X] AIR CRAFT TEST [] SPACE FLIGHT TEST [X]

OTHER (Specify) []

(Check one or more)

f) R&T BASE CANDIDATE 750K New Initiative

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY

None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

Develop optimized computational fluid dynamics processor

Improve numerical algorithms

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5. COMPONENT OR BREAKDOWN TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE R&T Base

NO. 1 M-3 2

Calculate Multiengine Base Flow Fields

THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

To develop the capability to calculate multiengine base flow fields and related base heating at low, med., and high altitude ranges.

3. NEED ANALYSIS

- a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [] LOW []
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [] OR ENHANCING: HIGH [X] MEDIUM [] LOW []
- e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [] SPACE FLIGHT TEST [X]
OTHER (Specify) [] (Check one or more)
- f) R&T BASE CANDIDATE 200K F.Y. 1978

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Adequate flight instrumentation is required on orbiter, ET, and SRB to verify model.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Better definition of exhaust plume flow field
Coupled boundary layer, inversed plume model (including F.R. chemistry)
3-D flow field model of reversed jet flow region
Solid motor radiation model that accounts for altitude changes
Improved short duration recovery temperature instrumentation

FORM NO. 1
PAGE 2 OF 2

TITLE	R&T Base
	Calculate Multiengine Base Flow Fields

NO. 1 M-3 2
THEME / W.G. / TASK

DATE 4 / 27 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Improve computer programs for calculations of exhaust plume flow fields to account for plume/external flow interactions, non-continuum effects. Include finite rate chemistry and coupled viscous/inviscid analysis for solid motor plumes.

Develop 3D base reversed flow field. Develop more accurate solid motor radiation model. Improve hot wire techniques for short duration testing.

7. ALTERNATIVE APPROACHES/OPTIONS Overly conservative base TPS design.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

[illegible][illegible]

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5. COMPONENT OR BREADBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL
OF STATE
OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE R&T Base - Development of Energy NO. 1 M-3 3
Conservative Aerothermodynamic Test
Facilities THEME / W.G. / TASK
DATE 4 / 26 / 1976

2. OBJECTIVE Achieve a significant reduction in energy required to
carry out aerothermodynamic research programs in ground-based
test facilities.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 4, WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1985
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☐ LOW ☒
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
f) R&T BASE CANDIDATE 2,200K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- o Develop improved data taking systems so that more data
points/hr. of test can be obtained.
- o Develop new test techniques that allow blow-down facilities
to be used where continuous-run wind tunnels are now used.
- o Develop efficient air storage and heater systems that reduce
energy requirements.
- o Develop miniaturized instrumentations that allow the use of
smaller (less expensive) models.
- o Devise means to recover waste heat from working fluid for
plant heating and cooling.

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE R&T Base - Development of Energy Conservative
Aerothermodynamic Test Facilities

NO. 1 M-3 3
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Perform feasibility assessment studies on facility operating and test data gathering systems to identify most promising candidate systems for improvement or development to significantly reduce energy requirements. For selected candidate system initiate design & development and incorporate into facility.

7. ALTERNATIVE APPROACHES/OPTIONS

Reduction in facility operating hours and increased reliance on theoretical and empirical methods.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

[illegible][illegible]

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Atmospheric Probes/Earth Return NO. 10 M-3 1
Vehicles - Heating and Flow Field THEME / W.G. / TASK
Definition including TPS Interaction DATE 4 / 26 / 1976

2. OBJECTIVE To reduce the uncertainties in heat shield environ-
ment by a significant advance in aerothermodynamic knowledge.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 3, WILL BE LEVEL ☒ 5 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1985
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☒ Earth Re-entry Verification (Check one or more)
f) R&T BASE CANDIDATE \$800K 506-26

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY NONE

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

Determine effect of mass transfer and roughness on B.L.
transition.

Determine radiative flux within shock/ablation layers

Determine reaction kinetics within shock/ablation layers.

Develop more accurate base flow-field and radiative flux
prediction techniques.

Extend present two-dimensional flow field analysis to three-
dimensions.

Extend experimental simulation for boundary layer transition
investigations.

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
OF STATE
OF ART

5. COMPONENT OR CREEDS/TO TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Atmospheric Probes/Earth Return Vehicles

NO. 10 M-3 2

Development of Stable Lifting and Non-

THEME / W.G. / TASK

Lifting Configurations Over Entire Speed

DATE 4 / 26 / 1976

Range

2. OBJECTIVE

Develop capability to accurately predict stability characteristics of a wide range of candidate probe vehicle configurations.

3. NEED ANALYSIS

a) LEVEL NOW ☐ 1, WILL BE LEVEL ☐ 5 UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☐ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1990

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☐ LOW ☒

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒

GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE \$200K 506-26

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR

USE OF THIS TECHNOLOGY (1) Definition of entry heating environment including TPS interactions. (2) Development of ability to identify configurations with optimum payload capability.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop 3-D, steady and unsteady flow field analyses.

Develop improved ground test techniques to obtain stability characteristics across the entire speed range including real gas hypersonic flows.

Carry out flight tests to validate ground test results and analyses.

Develop probe vehicles with loiter capability (thrust and/or deployable lifting surfaces) for long-time measurements in outer planet atmospheres.

5. COMPONENT OR BYPASS/BOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Exploration of Solar System/Surface NO. 10 M-3 3
Landers - Develop penetrator capability THEME / W.G. / TASK
DATE 4 / 26 1976

2. OBJECTIVE To develop the capability to place penetrators into the surface of terrestrial planets and outer planet satellites.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 3, WILL BE LEVEL ☒ 6 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 6 FOR OPERATIONAL SYSTEM USE BY DATE: 1984
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☒ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
f) R&T BASE CANDIDATE No funding F.Y. 1978

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Sensor development of meaningful subsurface measurements. High-g survival of sensors.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop technology to design light hypersonic decelerators
Develop technology to design low speed decelerators.

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Surface Landers - Develop Penetrator
Capability

NO. 10 M-3 3
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

First-stage high speed decelerators for planetary surface penetrators must be developed from several possible devices. Considerations in development include aerodynamic drag stability and heating. Investigations will be experimental in nature except for heating analysis. Second-stage low speed accelerators will be based on present practice in the Viking Project.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Decelerator Dev.																				
1st Stage (Mars)			Δ	—		▽			C											
2nd " (Mars)				Δ	—	▽			C											
1st Stage (Titan)							Δ	—			▽			C						
2nd " (Titan)									Δ	—	▽			C						

[illegible]

ORIGINAL PAGE #
OF POOR QUALITY

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Surface Landers
Plume-Surface Interaction Effects

--- Predict NO. 10/M-3/4
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

Develop the capability to predict the interaction flow field resulting from the interaction of the ground and plume when a rocket motor is used to land a vehicle on a planet's surface

3. NEED ANALYSIS

- a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1988]
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☐ MEDIUM ☒ LOW ☐
e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
f) R&D BASE CANDIDATE No funding F.Y. 1978

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY A definition of the face condition of
the planet and if required, the 3D character of the plume flow field.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

A pseudo-3D plume interaction flow field analysis that can adequately describe the plume as a blunt body approaches the end of the nozzle.

A small scale experimental program is required to verify math model.

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Surface Landers

NO. 10 M-3 4

Predict Plume-Surface Interaction Efforts

THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Develop analytical technique to describe plume flow interaction with surface as engine approaches surface.

Conduct experimental program using small engines and various surface materials to verify math model and to obtain an understanding of effects of plume on ground surface.

7. ALTERNATIVE APPROACHES/OPTIONS Base future designs on Viking experience

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE SURFACE LANDERS - OPTIMIZE

NO. 10/M-3/5

AERODYNAMIC CONFIGURATION FOR

THEME / W.G. / TASK

MAX PAYLOAD

DATE 4 / 27 / 76

2. OBJECTIVE

Develop capability to accurately analyze a wide range of
configurations and rationally choose among them

3. NEED ANALYSIS

a) LEVEL NOW 4, WILL BE LEVEL 5 UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1988

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☐ LOW ☒

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE \$200K 506-26

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY Definition of entry environment and
flow field including TPS interaction for candidate configurations

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop techniques for predicting 3D, real gas flow fields and
resulting aerodynamic characteristics for a wide range of potential
planetary probe vehicles.

Carry out ground and flight tests to validate theoretical predictions.

Identify relative payload capabilities of various configurations.

FORM NO. 1
PAGE 2 OF 2

TITLE Surface Landers - Optimize Aerodynamic Configuration for Maximum Payload

NO. 10 M-3 5
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Develop techniques for predicting 3-D, real gas flow fields and resulting aerodynamic characteristics for a wide range of potential planetary probe vehicles. Use a combined theoretical and analytical approach using the best available numerical analysis techniques and ground-based test facilities. Validate resulting techniques by shuttle-launched flight tests.

7. ALTERNATIVE APPROACHES/OPTIONS

Use existing state-of-the-art and accept

8. CURRENT/PLANNED RELATED ACTIVITIES (HTOP, OTHER)

Planetary Entry Aerothermodynamics (LaRC, ARC, JPL) 506-26

9. TECHNOLOGY SCHEDULES

[illegible]

FORM VI

WORKING GROUP M-3

DISCIPLINE TECHNOLOGY ANALYSIS

TECHNOLOGY NEED TITLE		NO.		SUPPORT ANALYSIS										GOAL ANALYSIS					
				IN CURRENT PROGRAM				NEW INITIATIVE			FY '78 \$ NOA		NEW WORK REQUIREMENT			COMMENTS		YES NO	
				SRT/OFFICE	RTOF NO.	R&T BASE	SYSTEM DEVELOP-MENT	EXPER-IMENT	SUP-PORT	NO.	SUPPORT %		NEW R&T BASE	MODIFY NEW INITIATIVE	NEEDS NEWER INITIATIVE				
1-M-3-1 (Increase Comp Fluid)									0	202	100	750k							X
1-M-3-2 (Multi-Fuel Base Flow)									0									X	
1-M-3-3 (Dev. Energy Cons. Fac)									0									X	
Probe/E Ret-Htg)				OAST	506-	X			70				X					X	
10-M-3-7 (Adv Pro/EA Ret-Conf)				OAST	506-26	X			70									X	
10-M-3-3 (Surf Ldrs-Pent Conf)				OSS	186-		X		0						X	Exp Reentry System	X		
10-M-3-4 (Surf Ldr Plumb)									0				X					X	
10-M-3-5 (Surf Ldr Aero Conf)				OAST	506-	X			0				X					X	
12-M-3-1 (Est. Aero-Thermo Des. Crit)				OAST	506-26	X			70	13A								X	
12-M-3-2 (Adv SFS Config. Char)				OAST	506-26	X			70	113E	100	1.6M						X	
12-M-3-3 (Adv STS Imp APS)				OAST	506-				70						X	Tech Base For AEOL	X		
12-M-3-4 (Adv SFS -AERO FL Test)				OAST	750-01	X			70	113A	100							X	
				OAST	750-03	X			80	113A	100							X	

SPACE TECHNOLOGY ADDITIONAL INITIATIVE

FORM IV

TITLE SHUTTLE-LAUNCHED EXPERIMENTAL RE-ENTRY

DATE 4/29/76

SYSTEM

TT NO. 10,12 OR WORKING GROUP NO. M-3

OBJECTIVE

To develop a specific shuttle-launched system which will include modularized building block booster elements, and basic experimental measurements, avionics guidance and command, and retrieval packages.

JUSTIFICATION

Implementation of such a system will provide flight aerothermodynamic data to validate ground facility experimental techniques, computational analyses, TPS materials and concepts; to calibrate planetary atmospheric science measurement techniques and to advance knowledge of high-speed re-entry phenomena.

TECHNICAL APPROACH/PLAN

Carry out trade-off studies to identify the most cost-effective method for using the shuttle as a launch platform for re-entry research vehicles. Carry out detailed analyses of possible re-entry experiments using the system. Design and construct the system. Use it with the shuttle to carry out flight research on planetary probe vehicles, hazardous waste disposal, aerobreaking of OTV, and buoyant station deployment.

SCHEDULE

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK																				
Optimized cost-effective sys.id.					△		▽													
Flight test feasibility studies					△		▽													
System Design							△		▽											
Const. & Checkout on shuttle								△		▽										
Research Flight Tests																				
a) planetary probes																				
b) waste disposal																				
c) buoyant stations											△			▽			0			
d) aerobreaking																				
e) AEOT														R						
MANPOWER (M.Y.)																				
INHOUSE (Profit & Non-Profit)					20	20	20	25	25	25	25	25	25	25						
TRACT					5	5	10	10	10	10	10	5	5	5						
FUNDING (10 ⁶ \$)					.5	.5	1.0	2.0	3.0	3.0	2.0	2.0	2.0	2.0						
INHOUSE TOTAL R&D																				
CONTRACT																				

PROPOSED LEAD CENTER

LaRC - Lead Center

ARC - Supporting Role

RECOMMENDATIONS FOR FULLER DEVELOPMENT OF INITIATIVE STATEMENT

SPACE TECHNOLOGY ADDITIONAL INITIATIVE

FORM IV

TITLE DEVELOPMENT OF THE TECHNOLOGY BASE FOR ADVANCEDDATE 4 / 29 / 76

EARTH-ORBIT TRANSPORTATION

TT NO. 12OR WORKING GROUP NO. M-3**OBJECTIVE**

To develop the technology base for future Earth-orbit transportation systems enabling improved performance at reduced cost.

JUSTIFICATION By the end of FY78, the most appropriate vehicle concepts and technology requirements must be identified for an advanced transportation system. This is needed so that concentrated efforts in critical technology areas may be initiated.

TECHNICAL APPROACH/PLAN

Current and planned studies within NASA and DOD will be used to identify the most promising vehicle configurations. From these configurations, concepts will be selected as a focus for concentrated development of the technology base. Approaches to technology development will be examined and feasibility studies conducted to determine maximum gain at minimum risk. Development of specific areas will be pursued as sub-elements of the program.

SCHEDULE

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK																				
Establish design & facility req'ts				Δ	▽															
Evaluate config. trade-offs				Δ		▽														
Develop mission & traffic models						Δ	▽													
Establish real-gas viscous effects, BL Trans.				Δ				▽												
Develop new shuttle borne experiments					Δ				▽											
Data base for sub-scale flight test veh.								Δ		▽										
Assess technology readiness										Δ		▽								
Support Development Program										Δ			▽		0					
MANPOWER (M-Y)																				
IN-HOUSE (Profit & Non-Pro)				90	90	100	110	120	120	110	100	90								
CONTRACT				4	4	5	5	6	6	5	4	3								
FUNDING (10⁶ \$)																				
IN-HOUSE R&D				.5	1.5	2.0	3.0	4.0	5.0	5.0	3.0	2.0								
CONTRACT																				

PROPOSED LEAD CENTER LaRC

RECOMMENDATIONS FOR FULLER DEVELOPMENT OF INITIATIVE STATEMENT